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Application of artificial intelligence in urban planning and urban management

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Abstract

The purpose of this research was to identify and elucidate the application of artificial intelligence in urban planning and management. To identify and analyze strengths, weaknesses, opportunities, and threats, the opinions of 25 managers, professors, and experts in urban planning and artificial intelligence were gathered using purposeful sampling. Research participants were selected based on criteria such as scientific publications in urban planning and artificial intelligence, a specialized doctorate in the field, and employment in urban management or municipalities. Semi-structured interviews were conducted to collect information on the opportunities, threats, strengths, and weaknesses of artificial intelligence in urban management and planning. Subsequently, weighting and ranking were performed using the Shannon entropy technique. After ranking, 18 opportunities, 13 threats, 15 strengths, and 14 weaknesses were identified. Employing the strategic planning quantitative matrix, indicators were scored and weighted. The total internal factor score was 2.469, and the total external factor score was 2.316, as depicted in the matrix. Tehaji's strategy was presented to formulate strategies for utilizing artificial intelligence in urban planning and management, resulting in an aggressive approach.

Keywords: artificial intelligence, urban planning, urban management, algorithm, strategy, SWOT
2020 MSC: 91D10, 97P80

1 Introduction

Today, half of the human population resides in cities, with this number steadily increasing annually. Simultaneously, the migration of most people to urban centers has led to significant advancements in urban characteristics such as technology, trade, government formation, resource consumption, and quality of life [17]. This rapid growth in recent centuries has engendered numerous problems like congestion, environmental pollution, and food and energy crises, which have persisted unabated in the 21st century, inflicting countless detrimental effects on societal environmental health [20]. Urbanization poses a contemporary challenge for urban officials and planners. As urban events become increasingly complex, so too must their management policies [25]. The extent and complexity of urban issues, coupled with the accelerating growth and development of cities, have transformed city management into a formidable task [11]. Consequences and problems arising from urban sprawl include the destruction of local communities, social

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segregation, increased costs for urban infrastructure and services, longer and more distant city commutes, heightened energy consumption, exorbitant public transportation costs, conversion of high-quality agricultural land and urban gardens, air pollution, and water source destruction and contamination. Collectively, these limitations and problems impede a city's attainment of sustainable urban development [8]. Urban developments and their populations have presented unprecedented challenges for urban management policies in the past two decades. The rapid growth of cities, outpacing the capabilities and resources of city managers, has transformed the provision of adequate city services into a substantial challenge [17]. A city's management model reflects the management situation of the entire country. The presence of managerial issues and neglect of influential groups can hinder a city's effective and proper management [2].

The structure of urban management has undergone significant transformations globally, influenced by evolving government regimes and economic systems. Traditional urban management approaches are inadequate for addressing complex contemporary urban challenges [5]. The global consensus is that the primary issue in urban management is not a lack of financial resources, technology, or skilled labour, but rather the ineffective management of these factors. Planning and administrative system challenges, though intangible, are more fundamental than overt urban issues because they create or exacerbate existing problems [10]. Weak institutional capacity, departmental isolation, lack of motivation for change, resistance to transformation, and inadequate government-local relationships hinder urban development. Fundamental reforms in urban planning and management are essential for reducing urban problems [6]. Cities are engines of development, and urban management is pivotal in shaping urban growth and improving settlements. Effective urban management is crucial for achieving sustainable and lawful development. It involves guiding cities towards holistic and sustainable growth, beyond mere problem-solving [8].

Contemporary cities grapple with rapid growth, creating complex issues like environmental pollution, housing shortages, traffic congestion, insecurity, infrastructure strain, and inadequate per capita services. Addressing these root causes is essential for achieving a desirable urban future [18]. Globalization and urban competition for resources and citizen welfare have led to negative consequences such as decreased belonging, loss of identity, societal polarization, and environmental decline. Counteracting these challenges requires wise and principled urban leadership instead of unbridled growth [18]. Various approaches have been proposed to mitigate these problems, including smart urban growth [11].

In recent years, the concept of smart cities has garnered significant attention. Numerous programs have been successfully implemented in major cities worldwide, with European cities such as Amsterdam, London, and Vienna serving as prime examples. Moreover, a comprehensive map of smart cities within the European Union has been developed [21]. The European Union spearheads the European Innovation Project for urban smart cities, which essentially involves extensive mapping and identification of smart cities within the Union. The Union's ongoing programs have validated the criteria for technological innovation processes and city solutions [5]. Conversely, Iran has encountered challenges due to various factors, particularly in inter-organizational cooperation and electronic citizen dimensions. Additionally, despite existing infrastructure, an integrated system capable of addressing needs under normal and critical conditions remains operational [26]. Consequently, adopting appropriate policies to create a smart city is imperative. Compared to developed countries, Iran faces greater challenges related to traffic, pollution, and urban economy, thus necessitating a strong reliance on smart cities and urban planning [19].

Artificial intelligence (AI) facilitates automated and intelligent decision-making in areas such as traffic, transportation, energy, and waste management. Leveraging advanced algorithms and neural networks, this technology enables simultaneous analysis of vast data volumes to support optimal city-wide decision-making [18]. Considering the impact of cities on societal sustainability, the agenda of creating smart cities transcends geographical boundaries. Accordingly, cities should prioritize the enhancement of service intelligence and undertake fundamental activities in this domain. This necessitates an open and intelligent architecture capable of delivering smart services to meet evolving city needs [20].

Advancements in AI technology have unlocked countless possibilities for urban improvement and development. As an advanced technology, AI offers numerous capabilities to optimize urban development and management processes. The convergence of AI and urban planning holds immense potential for creating smarter, more efficient, and sustainable cities [4]. By integrating advanced technologies, this combination fosters informed decision-making, optimal resource allocation, predictive analytics, and citizen participation. Recognizing AI as a valuable tool for addressing urban challenges, there has been a surge in the development of AI-based programs, software, and systems to support urban planning initiatives [16]. This research investigates the applications and challenges of artificial intelligence in urban planning and management.

2 Literature Review

2.1 Urban Management

The concept of urban management first surfaced in 1976 alongside other concepts like sustainable urban development and the healthy city project, incorporated into a United Nations development program agenda titled the "urban management program". This new concept and term emerged from a shift from centralized to decentralized management, emphasizing local management for urban development through local organizations [21]. Urban management involves organizing factors and resources to meet the needs of city residents. Its primary goal is to create a livable environment for all, characterized by social justice, economic efficiency, and environmental sustainability [6].

The term "urban management" was introduced in 1986 by the International Organization of Urban Management Program, supported by the World Bank, the United Nations Center for Human Settlements, and the United Nations Development Program, to address urban growth in developing countries. Essentially, the history of urban management science traces the city's emergence and the necessity of establishing principles, regulations, and rules for human life within biological, mental, and physical environments [25]. Urban management can be viewed as a systematic process of city growth and development, comprising two main components: management and the city itself [2]. Management entails decision-making encompassing planning, organizing, monitoring, and controlling, with these elements interacting. The city represents human creativity for a better life [1]. Figure 1 shows the applications of urban management in urban planning.

Figure 1: The applications of urban management in urban planning

Management knowledge revolves around five organizational functions: planning, organizing, staffing, directing, and controlling. This applies to urban management as well. Urban management is the responsibility of city government, encompassing all aspects of urban development, from private to public [8]. Based on its definition and practical duties, urban affairs management must plan for urban development and implement related programs, plans, and projects, assuming an executive planning role [1]. As an organizational framework for city development, urban management encompasses policies, programs, plans, and operations, aiming to coordinate population growth with access to basic infrastructure. It involves organizing agents and resources to respond to residents' needs [2]. Organization, planning, motivation, and creating motivation form the core of management. Since the city functions as a system and organization, urban management as a speciality is required to oversee city affairs [18]. The theoretical goal of urban management is to strengthen the urban development process [5]. Examining Iran's urban management reveals challenges stemming from centralization, exogenous urban plans, a rentier and oil-based economy, government control over urban management, and a deviation from integrated and systematic management. This has led to a backward approach to urbanization and its associated issues, trapped in top-down perspectives and attitudes [26].

2.1.1 Objectives of urban management

The most important goal of urban management is to enhance the living and working conditions of the resident population, encompassing diverse social and economic classes and groups, while safeguarding citizens' rights, fostering sustainable economic and social development, and preserving the physical environment. Consequently, when a mayor grapples with challenges such as urban health issues, environmental pollution, various social problems, and crises including housing shortages, inadequate public facilities, unemployment, low income, slums, social hardships, increased urban car ownership, and a lack of architectural identity, it is evident that urban management is facing difficulties and potential failure. In response, city management should concurrently address current urban issues and formulate future plans, envisioning an ideal future aligned with contemporary realities and conditions. Urban management holds the responsibility of protecting cities and the interests of their inhabitants [1].

2.1.2 Duties of city management

1. Developing essential infrastructure for efficient urban functioning.
2. Providing necessary services to cultivate human resources, enhance productivity, and improve urban living standards.
3. Regulating private sector activities impacting the security, health, and social welfare of the urban population.
4. Establishing essential services and facilities to support productive activities and efficient operations of private institutions within the city as a catalyst for development [19].

The role of urban management is paramount in shaping city development and enhancing urban settlements. From another perspective, urban management can be viewed as a cornerstone of legal and sustainable development. In this context, its significance is amplified as it orchestrates the optimal flow of urban life, contributing significantly to improved human settlements and sustainable urban development [3]. Urban management encompasses all institutions, organizations, and individuals involved in the urban management process, both formally and informally. It extends beyond the municipality or city council to include all entities contributing to urban governance [23].

2.2 Artificial intelligence

Artificial intelligence (AI) is a broad subfield of computer science dedicated to creating machines capable of simulating human intelligence. This technology is employed to address complex problems that conventional computational methods struggle to solve. The concept of artificial intelligence was introduced by John McCarthy in 1956, but its initial goals were unrealized due to technological limitations [4]. Between the 1960s and 1970s, researchers explored artificial intelligence through two primary avenues: knowledge-based systems (KBS) and artificial neural networks (ANNs) [23]. KBS systems are computers that offer advice based on human-provided knowledge and predetermined rules. In contrast, artificial neural networks are systems modelled after the human brain, comprising interconnected layers of nodes. These networks have been utilized in various fields such as medicine, biology, engineering, language translation, law, and construction [10]. During this period, interest in artificial intelligence waned until the 1980s due to the limited capabilities of artificial neural networks and a scarcity of data [8]. Since then, researchers have developed the gradient descent technique to minimize prediction errors. This method, known as backpropagation, is used to train artificial neural networks with multiple hidden layers and has been applied to a wide range of problems [2].

AI is a widely used term, however, it is not well understood by most people, including urban planners [17]. While the concept of integrating intelligence in machines and systems can be traced back to the 16th century, it was not until 1956 that the term AI was officially coined by computer scientists; John McCarthy, Allen Newell, Cliff Shaw, and Herbert Simon [3]. Back then, AI had yet to be further conceptualised to have a standard definition. Some informal definitions described AI as the capacity to accomplish goals in a variety of uncertain environments within highly adaptive, general-purpose systems through self-directed learning [22]. A single definition that provides a better, present-day understanding of the AI paradigm describes AI as the machine mimicry of human cognitive traits and actions in learning and problem-solving activities such as communication, reasoning, knowledge, perception, and planning [7].

What sets human cognitive abilities apart from AI is the difference in task execution. While humans automate tasks manually, AI can autonomously execute high-volume tasks reliably and efficiently. Moreover, AI can automate, repeat, learn, discover, and adapt to large datasets [17]. Previous computer-based approaches to data problem-solving exhibited limitations, such as handling vast quantities of data, graphs, or figures, or establishing relationships. AI emerged as a suitable solution to these challenges [14]. As depicted in Fig. 3, AI-enabled technologies address specific problem-solving tasks. Large datasets, often termed big data, are typically derived from IoT-enabled infrastructures. AI paradigms are formulated using these data. These paradigms are categorized as "Approaches" or tools based on: Logic—knowledge representation and problem-solving; Knowledge—ontology of concepts, information, and rules; "Probabilistic" methods—incomplete information and data; "Machine learning"—learning from historical data, including the subcategory "Deep learning"; "Embodied intelligence"—influencing the physical environment; and

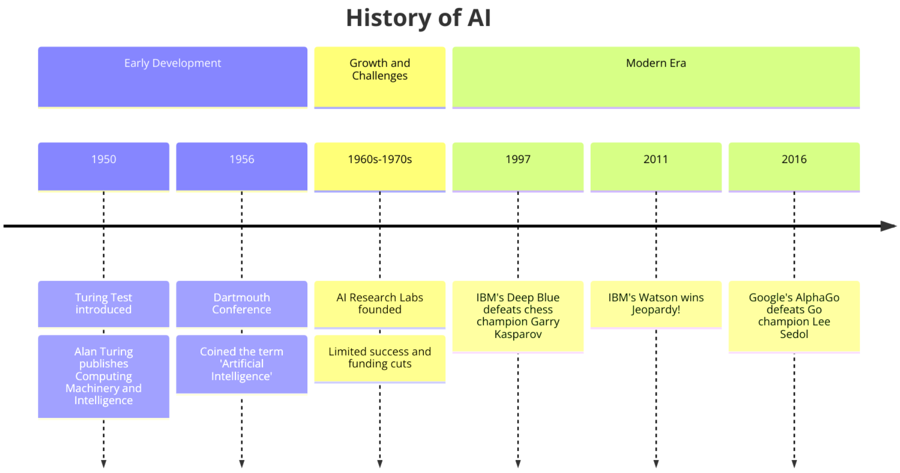

Figure 2: History of artificial intelligence

"Search and optimization"—intelligent search and optimal solutions. Diverse AI-enabled "Technologies" stem from these approaches, including "evolutionary algorithms, ambient computing, distributed AI, autonomous systems, artificial neural networks, probabilistic programming, decision networks, computer vision, and natural language processing" [13]

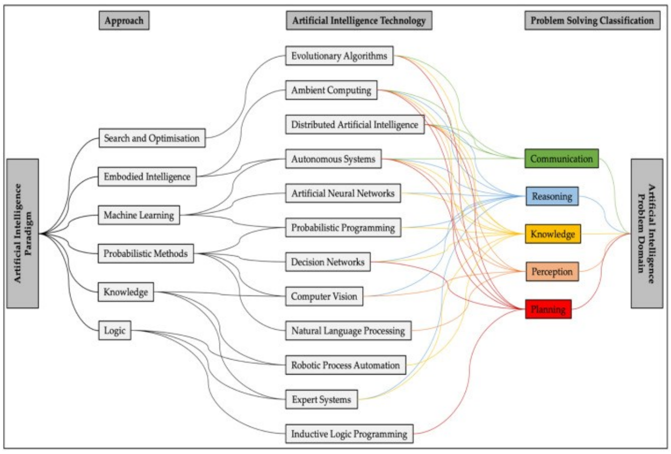

Figure 3: AI knowledge representation, derived from [7].

2.2.1 Artificial Intelligence and Urban Management

Artificial intelligence is defined as "the theory and development of computer systems capable of performing tasks that normally require human intelligence" and "enables machines to learn from experience, adapt to new inputs, and perform human-like tasks". Artificial intelligence encompasses both traditional machine learning and modern neural networks. By processing vast amounts of data, artificial intelligence systems are increasingly demonstrating human-like decision-making and planning abilities. As a rapidly evolving technology, artificial intelligence is employed by many countries in critical sectors. Iran has also made strides in this field, and it is necessary to implement strategies to further develop its artificial intelligence capabilities [5]. Due to their static nature, the old methods no longer address the dynamic needs of cities, hence the urgent need for rapid information circulation, real-time data utilization, and the achievement of dynamic urban management. Artificial intelligence, with its unique speed, facilitates dynamic urban management by enabling real-time data analysis. Today, cities generate countless data points: traffic information, surveys on parks, markets, parking lots, medical facilities, and school feasibility, and everything contributing to a more convenient and enjoyable urban life. Urban management, which involves anticipating future needs and planning accordingly, is greatly empowered by artificial intelligence, a potent tool for both identification and planning [3].

Artificial intelligence is a novel technology with immense potential in urban development. It can address urban challenges, enhance urban conditions, and catalyze urban transformations. As an emerging technology, it can revolutionize cities and urban development. Employing artificial intelligence in urban design can significantly improve citizens' lives and optimize urban development processes. However, effective utilization necessitates addressing challenges and obstacles. Moreover, government-private sector collaboration is essential for the success of artificial intelligence projects in urban development [12]. Figure 4 shows the applications of artificial intelligence in the field of urban management and urban planning.

Figure 4: Applications of artificial intelligence in urban management

Artificial Intelligence (AI) has the potential to transform urban management by enhancing decision-making, improving efficiency, and increasing the quality of services provided to residents.

3 Research method

This research includes identifying and explaining the capabilities of artificial intelligence in the aviation industry and air accidents, and in terms of the goal; in the qualitative part of the developmental type and the quantitative part; Applied and in terms of its nature, it is considered a descriptive-survey type of research. The collection tool in this research is a questionnaire, which has been used to prepare the questionnaire and compile the research literature using library methods, documents, interviews, the internet, etc. It should be noted that, in this research, with the help of Shannon's entropy and using the experience and knowledge of experts in the desired field and considering the characteristics of the study area, appropriate factors have been determined and weighted. One of the advantages of this method is its simplicity and documentation. First, according to the results obtained from the knowledge and experience of experts and the use of available information, weight has been assigned to each of the factors. In this way, first, the weights were calculated separately through expert knowledge and data, and then the desired weight was determined by comparing the obtained values.

To review and analyze the strengths and weaknesses, opportunities and threats, the opinions of 25 managers, professors, experts and experts in the field of artificial intelligence have been used. Selected people in this field include people who have books, articles, authorships, and translations in the field of aviation and artificial intelligence, and also have work experience as university professors, managers and consultants in terms of education and positions. -Postgraduate education in this field should be a field. First, a questionnaire designed during coordination was sent to the mentioned people in an open form via email, and after collecting the sent questionnaires, the contents were summarized based on the closest opinions. To reach a consensus, the questionnaire was sent and collected again, and this work continued until the desired result was obtained. According to the conditions of the research, in-depth interviews were also conducted with the expert community. After the finalization of the aforementioned dimensions and indicators, the knowledge, expertise and experiences of the expert community have been used to assign importance coefficients and weight them. As a result, the probability of mistakes will be reduced and the weights will be closer to reality.

First step: We formed the decision matrix. Second step: We normalized the matrix. The third step: calculating the entropy of each index: the entropy Ej is calculated as follows:

K as a constant value, we have kept the value of Ej between 0 and 1.

$$E_j = -k \sum_{i=1}^{m} P_{ij} \times Ln_{ij} \qquad i = 1, 2, \ldots, m.$$

Step 4: Next, we calculated the degree of deviation, which indicates how much useful information the relevant index (d_j) has provided to the decision maker. The closer the measured values of an index are to each other, it indicates that the competing options do not differ much from each other in terms of that index. Therefore, the role of that index in decision-making should be reduced to the same extent.

$$d_j = 1 - E_j.$$

Fifth step: Then the value of weight W_j is calculated and in fact the standard weight is equal to each d_j divided by the sum of $d_j s$.

3.1 SWOT matrix

The SWOT matrix is a table that organizes the internal and external factors into four categories:

Table 1: SWOT matrix

	Internal Factors	External Factors
Positive Factors	Strengths (S)	Opportunities (O)
Negative Factors	Weaknesses (W)	Threats (T)
Evaluation of internal and external factors	Strengths (S) List of aviation industry strengths	Weaknesses (W) List of weaknesses of the aviation industry
Opportunities (O) List of aviation industry opportunities	SO Strategies Take advantage of opportunities by leveraging strengths	WO strategies eliminate weaknesses by taking advantage of opportunities.
threats (T) List of threats to the aviation industry	ST Strategies Use strengths to avoid threats.	WT Strategies Minimize weaknesses and avoid threats.

The SWOT analysis method is a qualitative tool used to identify the Strengths, Weaknesses, Opportunities, and Threats associated with a particular project or strategy. While it is not typically based on mathematical formulas, it can be enhanced with quantitative methods to provide a more comprehensive analysis. Here's a representation of how SWOT analysis can be combined with some quantitative techniques:

3.2 Quantitative SWOT (TOWS Matrix)

The TOWS matrix is used to develop strategies based on the SWOT analysis. It combines the factors to suggest actions that leverage strengths and opportunities, or mitigate weaknesses and threats:

Table 2: Quantitative SWOT (TOWS Matrix)

	Threats (T)	Opportunities (O)
Strengths (S)	SO Strategies	ST Strategies
	Use strengths to exploit opportunities	Use strengths to avoid threats
Weaknesses (W)	WO Strategies	WT Strategies
	Overcome weaknesses by exploiting opportunities	Minimize weaknesses and avoid threats

3.3 Weight and Score Method

To make the SWOT analysis more quantitative, you can assign weights and scores to each factor:

Steps:

1. **List Factors**: Identify and list all relevant strengths, weaknesses, opportunities, and threats.
2. **Assign Weights**: Allocate a weight to each factor based on its importance (e.g., 0.0 to 1.0, with the total for each category summing to 1.0).

3. **Rate Factors**: Rate each factor on a scale (e.g., 1 to 5) based on its impact or significance.
4. **Calculate Weighted Scores**: Multiply the weight by the rating for each factor.
5. **Sum Scores**: Sum the weighted scores for each category.

Table 3: Example Weight and Score Method

Factor	Weight	Rating	Weighted Score
Strength 1	0.2	4	0.8
Strength 2	0.3	5	1.5
...	...	...	...
Total Strengths	1.0	-	Sum

3.4 SWOT factor scoring

You can use a scoring method to compare different strategic options by evaluating how well each option leverages strengths, overcomes weaknesses, exploits opportunities, and mitigates threats.

1. **Identify Strategic Options**: List different strategic options (e.g., Option A, Option B).
2. **Score Each Option**: Score each option based on how well it addresses each SWOT factor.
3. **Total Scores**: Calculate the total score for each option.

Table 4: Example SWOT Factor Scoring

Option	Strengths Score	Weaknesses Score	Opportunities Score	Threats Score	Total Score
Option A	8	-3	10	-5	10
Option B	7	-4	8	-2	9

3.5 SWOT quadrant analysis

A visual representation can also be used to plot strengths, weaknesses, opportunities, and threats in a quadrant diagram. This can help in visualizing the balance between internal and external factors.

- **X-Axis**: Internal Factors (Strengths to Weaknesses)
- **Y-Axis**: External Factors (Opportunities to Threats)

3.6 SWOT mathematical formula

While SWOT is inherently a qualitative method, these tables and steps show how quantitative techniques can be integrated to provide a more comprehensive and actionable analysis. While the SWOT analysis is primarily a qualitative tool, it can be complemented with quantitative methods to enhance decision-making. Below are some mathematical formulations that can be used to quantify SWOT factors and integrate them into decision-making processes:

3.6.1 Weight Assignment

Each SWOT factor can be assigned a weight based on its importance. The sum of the weights for each category (Strengths, Weaknesses, Opportunities, Threats) should be 1.

$$\sum_{i=1}^{n} w_i = 1 \sum_{i=1}^{n} w_i = \sum_{i=1}^{n} w_i = 1$$

where w_i is the weight of the i-th factor in a category (e.g., Strengths) and n is the number of factors in that category.

3.6.2 Scoring

Each SWOT factor can be rated or scored based on its impact or significance. Scores are typically assigned on a scale (e.g., 1 to 5 or 1 to 10).

3.6.3 Weighted score calculation

The weighted score for each factor is calculated by multiplying the weight of the factor by its score.

$$WS_i = w_i \times s_i WS_i = w_i \times s_i WS_i = w_i \times s_i$$

where WS_i is the weighted score of the i-th factor, w_i is the weight of the i-th factor, and s_i is the score of the i-th factor.

3.6.4 Total weighted scores

The total weighted score for each category (Strengths, Weaknesses, Opportunities, Threats) can be calculated by summing the weighted scores of all factors in that category.

$$TWS = \sum_{i=1}^{n} (w_i \times s_i) TWS = \sum_{i=1}^{n} (w_i \times s_i) TWS = \sum_{i=1}^{n} (w_i \times s_i).$$

3.6.5 Overall SWOT score

To compare different strategic options, the overall SWOT score can be calculated by considering the total weighted scores of all categories. This can be done by combining the total weighted scores of Strengths and Opportunities, and subtracting the total weighted scores of Weaknesses and Threats.

$$\begin{aligned}\text{Overall Score} &= (\text{TWSStrengths} + \text{TWSOpportunities}) - (\text{TWSWeaknesses} + \text{TWSThreats})\text{Overall Score} \\ &= (TWS_{Strengths} + TWS_{Opportunities}) - (TWS_{Weaknesses} + TWS_{Threats})\text{Overall Score} \\ &= (\text{TWSStrengths} + \text{TWSOpportunities}) - (\text{TWSWeaknesses} + \text{TWSThreats})\end{aligned}$$

4 Findings

At this stage, the internal factors related to both the innovations and challenges of applying artificial intelligence in urban planning and management have been identified (Table 2). In this study, each strength and weakness was assigned a weight between 0 and 1, ensuring that the total weight of internal factors equals 1. Additionally, a number between 1 and 4 was assigned to each strength and weakness based on its importance as determined by experts.

4.1 The matrix of external factors in the application of artificial intelligence in urban planning and urban management

To construct the External Factors Evaluation (EFE) matrix, we initially identify opportunities and threats, assigning a weight factor between zero (insignificant) and one (highly important) to each. The sum of these assigned weight coefficients must equal one. This weight is calculated using the Shannon entropy method. We then allocate points from 1 to 4 to each factor. A score of 1 signifies a severe threat, 2 a minor threat, 3 an opportunity, and 4 an excellent opportunity. The ranking is determined by these coefficients and ranges from 1 to 4. These numbers reflect the potential of artificial intelligence in the urban planning and management domain. The rankings are based on the effectiveness of these capabilities.

4.2 Matrix of internal factors of artificial intelligence application in urban planning and urban management

Internal factors are those within an organization that can be controlled by it. Strategists aim to leverage internal strengths while addressing weaknesses. After identifying key internal factors, experts assign weight coefficients, ranging from zero (insignificant) to one (highly important), to indicate the relative importance of each factor to the organization's success. The sum of these coefficients equals one. The ranking is based on these coefficients and assigned values of 1 to 4.

Table 5: Matrix of external factors of application of artificial intelligence in urban planning and urban management

Row	Opportunity	Coefficient	rank	score
O1	Improving decision-making and urban planning	0.08	4	0.094
O2	Traffic management and congestion reduction using real-time data analysis	0.06	4	0.113
O3	Predicting natural disasters and possible crises using advanced models and historical data	0.08	3	0.092
O4	Improving public services through robots and intelligent systems.	0.07	3	0.105
O5	Designing sustainable projects with data analysis to manage energy consumption	0.03	2	0.088
O6	Optimizing energy consumption in buildings and infrastructures and reducing energy demand.	0.03	3	0.109
O7	Garbage collection, street cleaning and infrastructure maintenance using intelligent robots	0.05	4	0.092
O8	Increasing citizens' participation in urban decision-making processes using online platforms.	0.04	3	0.083
O9	Using data analysis to make strategic decisions and improve management processes.	0.03	2	0.092
O10	Predicting natural disasters by analyzing historical weather data and sensors.	0.04	3	0.113
O11	Developing a smart economy by promoting innovation and entrepreneurship.	0.05	4	0.097
O12	Helping architects and planners in the optimal design of urban spaces according to the needs and behavioral patterns of citizens.	0.04	4	0.103
O13	Simulating and analyzing the effects of new urban projects, such as constructions and infrastructure development.	0.03	3	0.098
O14	Using facial recognition and video analysis technologies to increase security and respond quickly to incidents	0.02	2	0.112
O15	Prediction and control of water consumption, leakage detection and efficient management of water resources	0.02	3	0.099
O16	Optimizing public and private transportation routes using AI algorithms	0.08	2	0.107
O17	Traffic forecasting and adjusting traffic lights based on traffic volume in real time.	0.06	2	0.083
O18	Using intelligent systems to coordinate and manage rescue operations	0.08	1	0.084
Row	Threats	Coefficient	rank	score
T1	Potential violations of privacy and data security through the collection and analysis of large amounts of information	0.03	3	0.043
T2	Disruption of urban systems due to technical failures or cyberattacks	0.02	3	0.072
T3	Possibility of errors in data analysis and defects in data	0.03	2	0.062
T4	Potential disregard for human values and moral principles	0.02	2	0.051
T5	Discrimination or unfairness in service delivery due to unequal access to AI technology	0.02	2	0.065
T6	Significant costs associated with developing, implementing, and maintaining AI systems	0.01	2	0.044
T7	Time-consuming and costly training and adaptation of human resources to new technologies	0.03	1	0.031
T8	Unemployment and job displacement due to AI automation of tasks	0.02	1	0.083
T9	Potential use for malicious purposes such as disrupting urban infrastructure	0.02	1	0.042
T10	Lack of appropriate legal and regulatory frameworks for AI use	0.03	1	0.072
T11	Resistance to the adoption of artificial intelligence	0.01	1	0.035
T12	Misinterpretation of human goals and unexpected actions by AI	0.03	1	0.063
T13	Loss of control over machines due to their ability to learn and make autonomous decisions	0.02		0.042
	total	1		2.469

A factor evaluation matrix was employed to determine the chosen strategy. This matrix incorporates the strengths, weaknesses, opportunities, and threats (SWOT) of artificial intelligence (AI). The final score for each factor is calculated based on its ranking and score coefficient. The SWOT matrix enables the formulation of four distinct strategic options: defensive, adaptive, contingent, and offensive. These strategies are grounded in a combination of internal and external factors influencing AI. In practical terms, various strategies might overlap or be concurrently implemented. Given the present state of AI capabilities, four categories of strategies can be discerned, each characterized by a different level of activity.

Strategic analysis constitutes a critical step in the strategic planning process. At this juncture, the organization's position is assessed concerning its internal strengths and weaknesses, as well as external opportunities and threats. The analysis encompasses three fundamental steps:

1. Evaluation of key factors influencing the organization's mission and vision realization within the internal environment. (weaknesses - strengths)

2. Evaluation of key factors influencing the organization's mission and vision realization within the external environment. (opportunities - threats)

3. Situational assessment and strategic action.

Table 6: Matrix of Internal Factors of Artificial Intelligence Application in Urban Planning and Urban Management

Row	Strengths	Coefficient	rank	score
S1	The ability to process and analyze vast amounts of data rapidly and accurately.	0.07	4	0.099
S2	Capacity for continuous improvement in urban systems.	0.06	4	0.102
S3	Enhanced efficiency in urban operations and cost reduction through process automation and optimization.	0.04	3	0.113
S4	Provision of innovative solutions for novel and complex urban challenges.	0.04	3	0.107
S5	Increased efficiency and time and cost savings in urban operations.	0.03	2	0.113
S6	Automation of repetitive and mundane tasks.	0.03		0.093
S7	Automation of multiple tasks and process optimization is essential.	0.05	3	0.109
S8	Data and behavioral pattern analysis for crime prediction and prevention.	0.04	4	0.113
S9	Prediction and control of water consumption, leak detection, and efficient water resource management.	0.04	3	0.097
S10	Assistance for drivers in finding available parking spaces and traffic control.	0.03	2	0.103
S11	Reduction of human error in data analysis and expedited decision-making.	0.05	3	0.117
S12	24/7 accessibility and continuous operation capability.	0.04	4	0.103
S13	More accurate decision-making due to unbiased perspective.	0.03	4	0.098
S14	Machine learning enables systems to learn from data and improve performance over time.	0.05	3	0.122
S15	Pre-defined algorithms allow for use in high-risk situations where human safety is compromised.	0.04	2	0.099
Row	Weakness	Coefficient	rank	score
W1	Inability to adapt to human and moral characteristics	0.04	3	0.072
W2	Lack of clear and unified standards for the use of artificial intelligence	0.03	3	0.062
W3	Only able to perform planned and one-dimensional tasks	0.03	2	0.051
W4	There is a risk of losing control over their actions.	0.03	3	0.065
W5	Over-reliance on AI in decision-making can lead to a decline in critical thinking, creativity and human intelligence.	0.02	2	0.044
W6	Lack of public trust prevents the adoption and effective use of these technologies.	0.02	3	0.031
W7	AI algorithms can inherit biases in the data they are trained on.	0.03	2	0.083
W8	Deepfake videos and audio generated by artificial intelligence can be used to manipulate public opinion and spread false information.	0.02	2	0.042
W9	Making decisions based on "black box" algorithms and the lack of understanding of these algorithms for the public.	0.02	1	0.072
W10	lacks creativity and intuition in performing activities that are not foreseen.	0.03	1	0.035
W11	Limited access and quality of data required for effective development and implementation of artificial intelligence systems.	0.01	2	0.023
W12	Potential reduction of human interactions	0.03	1	0.052
W13	Data privacy and security concerns	0.02	2	0.049
W14	The development of autonomous weapons using artificial intelligence raises ethical and security concerns.	0.03	1	0.047
	total	1		2.316

4.3 Internal and External Matrix

To simultaneously analyze internal and external factors, the internal and external matrix is utilized. This matrix incorporates scores derived from both internal and external factor evaluations. The scores obtained from the Internal Factor Evaluation (IFE) are plotted on the horizontal axis, while those from the External Factor Evaluation (EFE) are plotted on the vertical axis.

Within this square matrix, scores are categorized into two spectrums: strong (2.5 to 4) and weak (1 to 2.5). The strategic implications are as follows: if positioned in the first quadrant, a growth and development strategy is recommended; if in the second quadrant, a conservative strategy (maintenance and external support) is suitable; if in the third quadrant, a defensive strategy is appropriate; and if in the fourth quadrant, a competitive strategy is advisable. By employing the IE matrix and positioning the scores from the internal and external factor evaluation matrices, the strategic position was determined to be in the first region. Consequently, competitive strategies (SO) will be selected accordingly.

Evaluation of Internal Factors (IFE): 2.469

Evaluation of External Factors (EFE): 2.316

Since the area marked with red and blue colors is the aggressive strategy area, we will continue to present aggressive strategies in the internal and external environment.

Job displacement and unemployment: To address this issue, it's essential to train and retrain the workforce to acquire new and diverse skill sets. Additionally, creating novel and flexible job opportunities for human capital in areas where artificial intelligence is less capable is crucial. Implementing laws and regulations to safeguard workers' rights amidst job transitions is also necessary.

Security and Privacy Protection: The rights and responsibilities of both citizens and machines regarding the access, use, preservation, and deletion of personal data must be defined. Robust security and encryption systems should be established to safeguard personal data from theft, intrusion, and alteration. Policies and laws should be enacted to prohibit or restrict the collection and use of personal data without explicit consent from data owners. Additionally, public awareness and education campaigns should be implemented to inform individuals about privacy risks and protective measures within the realm of artificial intelligence.

Reduce costs: Artificial intelligence has significant potential to improve the efficiency, sustainability, and quality of life in cities. However, the costs of developing and implementing AI systems can be challenging. To address this issue, it is preferable to focus on projects that bring the most return on investment. Start with small, controllable projects and gradually move to larger, more complex ones. Utilize open-source platforms and AI tools whenever possible. Collaborate with other cities and organizations to share data, models, and resources, and employ cost-effective and scalable infrastructure. Combine AI models with traditional methods.

Loss of Control: To address this challenge, clear and precise objectives and limitations for AI that align with human values and principles should be established. Additionally, monitoring and control mechanisms should be implemented to assess and correct AI behaviour, and an international organization should be created to regulate and enforce AI standards, laws, and ethics.

5 Conclusion

The use of artificial intelligence in urban planning and urban management can be considered as a powerful tool in improving the quality of life and improving the efficiency of urban systems. Artificial intelligence (AI) is rapidly becoming a powerful tool for urban planning and management. AI's ability to process huge amounts of data, and identify patterns and predictions, has created new opportunities to solve complex urban challenges and improve the quality of life of city dwellers. Smarter and more efficient cities can be created by taking advantage of opportunities such as improving decision-making and urban planning, optimal traffic management, forecasting and crisis management, increasing the efficiency of public services, sustainable urban development and improving the quality of life of citizens. By analyzing big data and using advanced algorithms, artificial intelligence enables better management of resources and providing personalized services. It can be used to analyze demographic data, such as age, gender, income, and education level, to understand the needs of city residents better. It can be used to model urban growth and predict future housing, infrastructure, and services demand. It can be used to design new neighbourhoods, parks, and other public spaces that are both sustainable and livable. It can also be used to collect citizen feedback on various issues through surveys, social media, and other channels.

However, threats such as security and privacy issues, over-reliance on technology, unfairness and discrimination, need for high investment and manpower training and adaptation must also be carefully managed. These threats can create serious challenges for the successful implementation of intelligent systems and require careful attention and planning. The strengths of artificial intelligence include the ability to analyze and process large data, continuous technological advances, increased efficiency and reduced costs, and the possibility of implementing innovative solutions. These strengths can help improve management decisions and improve the quality of urban services. However, weaknesses such as the complexity of implementation, lack of specific standards, issues related to public acceptance and trust, and data limitations must also be taken into account to ensure the full success of this technology in the field of urban planning and urban management. In general, artificial intelligence has a high potential for transformation in urban planning and urban management, but it requires careful planning, risk management and proper investment to serve society in the best possible way and create positive changes in the lives of citizens.

With the advancement of artificial intelligence technology, new and innovative applications for urban planning and management will emerge. It is important to establish appropriate legal and regulatory frameworks for the use of artificial intelligence in these fields. Various stakeholders, including governments, the private sector and civil society, must work together to ensure that AI is used for the collective good. In general, it can be said that artificial intelligence is a powerful tool that can be used to improve urban planning and management. By using artificial intelligence responsibly and ethically, we can create more sustainable, efficient and livable cities for all.

References

[1] Z. Allam and Z.A. Dhunny, *On big data, artificial intelligence and smart cities*, Cities **89** (2019), no. 4, 80–91.

[2] M. Arzani Birgani and O. Kohzadi Seyf Abad, *Evaluative analysis Procedural challenges of urban management with a content analysis approach Granheim and Landmann (Case study: Metropolis Ahvaz)*, Urban Design Discourse: Rev. Contemp. Lit. Theor. **2** (2021), no. 2, 85–105.

[3] I. As, P. Basu, and P. Talwar, *Artificial Intelligence in Urban Planning and Design: Technologies, Implementation, and Impacts*, Elsevier, 2022.

[4] M. Ayini, *Exploring the challenges of urban management in new Iranian cities based on structural equation modeling (SEM)*, Quart. J. Urban Reg. Dev. Plann. **4** (2019), no. 9, 115–146.

[5] M. Bafghizadeh, P. Soleimani Moghadam, and N. Jahanneya, *Investigating and identifying the challenges and crises of urban management in Ahvaz metropolis*, Geog. Human Rel. **4** (2021), no. 2, 415–432.

[6] S.A.A. Bokhari and S. Myeong, *Artificial intelligence-based technological-oriented knowledge management, innovation, and e-service delivery in smart cities: Moderating role of e-governance*, Appl. Sci. **12** (2022), no. 17, 1–20.

[7] F. Corea and F. Corea, *AI knowledge map: How to classify AI technologies*, An introduction to data: Everything you need to know about AI, big data and data science, Springer, 2019.

[8] F. Cugurullo, *Urban artificial intelligence: From automation to autonomy in the smart city*, Front. Sustain. Cities **2** (2020), no. 38, 1–14.

[9] M. De Carlo, G. Ferilli, F. d'Angella, and M. Buscema, *Artificial intelligence to design collaborative strategy: An application to urban destinations*, J. Bus. Res. **129** (2021), no. 2, 936–948.

[10] Z. Engin, J. Van Dijk, T. Lan, P.A. Longley, P. Treleaven, M. Batty, and A. Penn, *Data-driven urban management: Mapping the landscape*, J. Urban Manag. **9** (2020), no. 2, 140–150.

[11] C.A. Freire, F.A. Ferreira, E.G. Carayannis, and J.J. Ferreira, *Artificial intelligence and smart cities: A DEMATEL approach to adaptation challenges and initiatives*, IEEE Trans. Engin. Manag. **70** (2021), no. 5, 1881–1899.

[12] Y. Gao, *Design of urban innovation space system using artificial intelligence technology and internet of things*, Heliyon **10** (2024), no. 3, 1–12.

[13] A. Haldorai, A. Ramu, S. Murugan, A. Haldorai, A. Ramu, and S. Murugan, *Artificial intelligence and machine learning for future urban development*, Computing and Communication Systems in Urban Development: A Detailed Perspective, 2019, pp. 91–113.

[14] H. Herath and M. Mittal, *Adoption of artificial intelligence in smart cities: A comprehensive review*, Int. J. Inf. Manag. Data Insights **2** (2022), no. 1, 100076.

[15] S.J. Mikhaylov, M. Esteve, and A. Campion, *Artificial intelligence for the public sector: Opportunities and challenges of cross-sector collaboration*, Phil. Trans. Royal Soc. A: Math. Phys. Engin. Sci. **376** (2018), no. 2128, 1–21.

[16] R. Nishant, M. Kennedy, and J. Corbett, *Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda*, Int. J. Inf. Manag. **53** (2020), no. 2, 102104.

[17] A. Ortega-Fernández, R. Martín-Rojas, and V.J. García-Morales, *Artificial intelligence in the urban environment: Smart cities as models for developing innovation and sustainability*, Sustainability **12** (2020), no. 19, 7860.

[18] S.J. Quan, J. Park, A. Economou, and S. Lee, *Artificial intelligence-aided design: Smart design for sustainable city development*, Envir. Plann. B: Urban Anal. City Sci. **46** (2019), no. 8, 1581–1599.

[19] S. Rezaie Eshaghvandi and A. Fathi, *Measuring and ranking the challenges facing uUrban management in Kermanshah City*, J. Sustain. Urban Reg. Dev. Stud. **1** (2020), no. 1, 97–114.

[20] T.W. Sanchez, H. Shumway, T. Gordner, and T. Lim, *The prospects of artificial intelligence in urban planning*, Int. J. Urban Sci. **27** (2023), no. 2, 179–194.

[21] T.H. Son, Z. Weedon, T. Yigitcanlar, T. Sanchez, J.M. Corchado, and R. Mehmood, *Algorithmic urban planning*

for smart and sustainable development: Systematic review of the literature, Sustain. Cities Soc. **94** (2023), no. 1, 104562.

[22] Z. Ullah, F. Al-Turjman, L. Mostarda, and R. Gagliardi, *Applications of artificial intelligence and machine learning in smart cities*, Comput. Commun. **154** (2020), no. 4, 313–323.

[23] A. N. Venkatesh, M. Naved, A.H. Fakih, P.R. Kshirsagar, and P. Vijayakumar, *An approach for smart city applications using artificial intelligence*, AIP Conf. Proc. **2393** (2022), no. 1.

[24] K. Wang, Y. Zhao, R.K. Gangadhari, and Z. Li, *Analyzing the adoption challenges of the Internet of things (Iot) and artificial intelligence (AI) for smart cities in China*, Sustainability **13** (2021), no. 19, 10983.

[25] T. Yigitcanlar, J.M. Corchado, R. Mehmood, R.Y.M. Li, K. Mossberger, and K. Desouza, *Responsible urban innovation with local government artificial intelligence (AI): A conceptual framework and research agenda*, J. Open Innov.: Technol. Market Complexity **7** (2021), no.1, 1–16.

[26] T. Yigitcanlar, K.C. Desouza, L. Butler, and F. Roozkhosh, *Contributions and risks of artificial intelligence (AI) in building smarter cities: Insights from a systematic review of the literature*, Energies **13** (2020), no. 6, 1473.